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Explaining Commuter Transport Choice During the COVID-19 Pandemic: A Study Based on the Theory of Planned Behavior

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Abstract

Little is known about what influenced mobility behavior in Brazil during the COVID-19 pandemic. This study, grounded in the Theory of Planned Behavior, aims to examine how Brazilians decided on their mode of transportation during this period. An online survey was conducted with 404 individuals working in person. The results indicated that: 1) the main reason for choosing the transport mode was time-saving, followed by comfort and the perceived risk of contracting COVID-19; 2) there was a significant increase in the use of personal vehicles compared to public transportation at the onset of the pandemic; 3) participants demonstrated positive attitudes toward individual transport modes, such as cars; and 4) attitudes and subjective norms significantly predicted the choice of the car and public transport. These findings are discussed in terms of having more sustainable and safer transportation choices.

Keywords: travel mode choice, face-to-face workers, COVID-19, Brazil, behavioral intention.

Elección del Transporte Durante la Pandemia de Covid-19: un Estudio Basado en la Teoría del Comportamiento Planificado

Resumen

Poco se sabe sobre lo que influyó en el comportamiento de movilidad en Brasil en relación con la COVID-19. Utilizando la Teoría del Comportamiento Planificado, el objetivo de este estudio es comprender cómo los brasileños eligieron qué modo de transporte utilizar durante este escenario. Una muestra de 404 personas, que trabajaban de manera presencial, participó en una encuesta en línea. Los resultados indicaron que: 1) el principal motivo para elegir el modo de transporte fue el ahorro de tiempo, seguido de la comodidad y el riesgo de contraer COVID-19; 2) hubo un aumento significativo en el uso de vehículos personales en comparación con el uso del transporte público al comienzo de la pandemia: 3) hubo actitudes positivas con los medios de transporte individuales como el automóvil; y 4) actitudes y normas subjetivas significativamente predicho la elección del coche ante el transporte público. Estas conclusiones se discuten en términos de una elección del medio de transporte más sostenible y seguro.

Palabras clave: elección de modo de viaje, trabajadores presenciales, COVID-19, Brasil, intención de comportamiento.

1. Introduction

In Brazil, the annual traffic fatality rate is alarming, with 19.7 deaths per 100,000 inhabitants (WHO, 2018). Most fatalities involve motorcycle users (36.7%) and car users (21.4%), whereas buses are considered the safest mode of transport (Brasil, 2020a). Modal choices can also significantly impact air pollution, another critical public health concern (Blount et al., 2017).

Measures that governments can adopt to improve air quality and public health include the development of safer and more accessible public transport systems, promoting walkability, and implementing mandatory inspections and emissions standards for vehicles (WHO, 2022). However, public transport in Brazil is often characterized by long waiting times, discomfort during commutes, and inadequate infrastructure for walking and cycling (Vasconcellos, 2018).

Recently, the use of public transport has been related to the risk of contracting COVID-19 reduction in its usage (Oliveira et al., 2020). Consequently, somecities have sought to become more bike-friendly, triggering the building of more infrastructure for cyclists (Nikitas et al., 2021) —which can also contribute to reduce harmful environmental effects (e.g., greenhouse gases).

Little is known, however, about what influences mobility behavior in Brazil and how a different context, such as the pandemic, might affect mobility choices. The aim of this study is to understand how workers in two large Brazilian cities choose which transport mode to use to get to work. In the following sections, we will provide the context in which the study was carried out, data on choice of transport modes as well as our rationale for using the Theory of Planned Behavior (TPB; Ajzen, 1991).

1.1. Context

This study focuses on two cities: Curitiba and São Paulo. Curitiba, located in the southern region of Brazil, was chosen due to its high-quality public transport system, which is considered exemplary by Brazilian standards (Vasconcellos, 2018). The city is recognized as the birthplace of the Bus Rapid Transit (BRT). This system was developed in the 1970s by a multidisciplinary team, inspired by other cities around the world, with the aim of optimizing public transport in Curitiba. BRT's main feature is dedicated bus lanes, of which the city now has 81 km (Duarte et al., 2016).

Improvements have continued over time. In 1992, for example, the city began operating the "Biarticulated Express Line Bus", which used the same structure as previously developed, but with greater passenger capacity (Prestes et al., 2022). Another improvement was the level boarding, for instance, access from passenger platforms to the bus floor (Duarte et al., 2016). The system has a network of feeder lines and is considered integrated, as passengers can change lines at bus terminals (22 interchange terminals) and pay only one fare, collected before boarding (Duarte et al., 2016).Following the implementation of BRT in Curitiba, the city gained recognition in the urban planning field for prioritizing public over private transport (Prestes et al., 2022). Several cities in Brazil (e.g., Rio de Janeiro, Goiânia, São Paulo; Faria, 2018) and around the world (e.g., Bogotá; Duarte et al., 2016) have replicated this model, adapting it to their socio-spatial differences. In Brazil, the BRT replication process was intensified in the mid-2000s (Faria, 2018).

São Paulo, located in southeastern Brazil, is the country's most populous city, with over 11 million residents —6.5 times the population of Curitiba (Brasil, 2022)— and is also one of the most globalized cities in the world. Unlike Curitiba, São Paulo's public transport system includes subways and trains in addition to buses (São Paulo, 2022b). Both cities have high car ownership rates, with approximately one car for every two residents (Brasil, 2020b). Excessive reliance on motorized vehicles has led to congestion, air pollution, and high crash rates, so governments need to rethink mobility policies (Oliveira & Silva, 2015). Understanding

how people choose their transport mode is essential for developing these policies.

1.2. Reasons for choosing the transport mode

Among the main factors considered when making the modal choice are time-saving (Delhomme & Gheorghiu, 2016; Maia et al., 2020), financial cost, health promotion (Maia et al., 2020; Useche et al., 2019), safety (in relation to traffic crashes or thefts/robberies that may occur on the way), comfort (Maia et al., 2020) and concern for the environment (Delhomme & Gheorghiu, 2016; Maia et al., 2020; Useche et al., 2019).

To encourage the adoption of environmentally friendly transport modes, urban infrastructure measures —such as bicycle lanes and parking— are critical (Yang et al., 2018). Electric vehicles also present a viable alternative, provided adequate charging stations are available (Chen et al., 2018).

Demographic factors can influence environmental attitudes. Women and older adults tend to exhibit more pro-environmental behaviors (Casaló & Escario, 2018; Domingues & Gonçalves, 2018). Women are more likely to use public transport (Vicente-Molina et al., 2018) and stop using their car for environmental reasons (López-Mosquera et al., 2015).

Recently, another factor may have influenced the choice of transport modes on a global level: the risk of contracting COVID-19. More than 705,000 Brazilians have died because of the pandemic (Brasil, 2023). Proportionally, more people died in Curitiba (4.37 per million; Curitiba, 2022) than in São Paulo (3.57 per million; São Paulo, 2022a). To contain the spread of the disease, social distancing was recommended (WHO, 2020).

Public transport usage declined during the pandemic, as individuals sought to avoid contact with other people and shared objects (Aaditya & Rahul, 2021; Jenelius & Cebecauer, 2020). For instance, daily public transport trips in Curitiba dropped: in 2019 there was an average of 1,331,610 passengers per day, while in 2020 there were 710,589 (Urbanização de Curitiba, 2022). To improve the attractiveness of this type of transport post-COVID-19, one option is fare-free public transport policies, which have been effective in Chinese cities (Dai et al., 2021). Public transport providers need to reduce passengers' anxiety and restore their confidence in it (Dong et al., 2021).

Conversely, active transport modes, such as cycling and e-scooters, have gained popularity during the pandemic (Dias et al., 2021; Fenu, 2021). A study carried out in Spain showed that most of the population agrees with expanding spaces for pedestrians and cyclists and would change their mode of transport to a more sustainable one if this reduced the spread of COVID-19 (Awad-Núñez et al., 2021). The pandemic has prompted many cities to rethink their transport systems, highlighting the need for innovative approaches to urban mobility (Vickerman, 2021). We present here our approach to how such "rethinking" can occur.

1.3. Theory of Planned Behavior

To understand the choice of travel modes during the pandemic, the present study is based on the Theory of Planned Behavior (TPB; Ajzen, 1991). According to this theory, a person's actions are guided by four key components:

- **Attitude,** shaped by the perceived consequences of a behavior and whether these consequences are evaluated positively or negatively.
- **Subjective norms,** generated by the expectations of other people, who are considered important (family, co-workers) regarding the behavior in question.
- **Perceived Behavioral Control** *(PBC),* determined by the existence of factors that may facilitate or hinder the execution of the behavior, such as skills, financial resources, or other necessary elements.
- **Intention**, which refers to the willingness or expectation to perform the behavior.

There are two types of subjective norms: injunctive norm, when there is an expectation or probability that important people would approve

or disapprove the behavior, and descriptive norm, when these important people perform the behavior or not (Fishbein & Ajzen, 2010). Bamberg et al. (2003) have provided support for using the TPB as a theoretical framework for studies on travel mode choice.

1.4. Hypotheses

According to the objective of this study and the existing literature in Traffic Psychology, four hypotheses were developed and tested:

H1: The pandemic can influence the choice of transport mode to the extent that: a) there was an increase in car use during the pandemic compared to before the pandemic (Aaditya & Rahul, 2021); b) participants who used public transport before the pandemic and who have changed their modal choice are more concerned about contracting COVID-19 compared to those who have not changed (Jenelius & Cebecauer, 2020).

H2: The reasons for choosing transport modes vary by gender, age, city, and the perceived freedom to choose. a) Curitiba residents consider the risk of contracting COVID-19 more significant than São Paulo residents, because proportionally more people in Curitiba died from this disease than in São Paulo (Curitiba, 2022). b) Females and older adults display more pro-environmental behavior when choosing transport modes compared to males and younger individuals (Casaló & Escario, 2018; Domingues & Gonçalves, 2018; López-Mosquera et al., 2015). c) Financial cost is a greater consideration for the mode of choice among users who do not feel they can freely choose either public or privately owned transport compared to those who do feel free to choose; on the other hand, "free" users (with a higher sense of freedom to choose) are more concerned about comfort than non-free commuters when choosing the mode of transport (Maia et al., 2020).

H3: In Brazil, individuals who exclusively use private transport have more positive attitudes toward these modes compared to those who rely solely on public transport (Vasconcellos, 2018).

H4: Attitudes and subjective norms can predict the use of public transport and cars for commuting to work (Ahmed et al., 2021; Nemme & White, 2010). In contrast, Perceived Behavioral Control may not exert a significant influence during the pandemic.

To test these hypotheses and understand how Brazilian adults chose their commuting modes during the COVID-19 pandemic (defined for this study as the period between July and November 2021), an online survey was conducted using a questionnaire based on the TPB framework (Ajzen, 1991).

2. Material and Methods

2.1. Participants

Participants had to meet the following eligibility criteria: 1) work in person (not remotely), 2) reside in Curitiba or São Paulo, and 3) be 18 years of age or older. The sample included 404 Brazilians. A sample size of 385 individuals was initially expected, based on a 5% margin of error and a 95% confidence level, considering a population of 6,904,053 workers in Curitiba and São Paulo (IBGE, 2022). Participants had an average age of 34.24 years (± 11.07 years). The mean distance traveled between home and work was 10.49 km (± 10.55 km): 9.48 km (± 8.83 km) for Curitiba residents and 12.39 km (± 13.00 km) for São Paulo residents. There were more participants working in the health sector (24.3%) than in any other sector.

In the questionnaire, participants were asked to self-declare their gender. The options were "male", "female" or "other". The "other" option was not chosen. Table 1 presents the main information about the participants.

2.2 Instruments

To prepare the questionnaire, Fishbein and Ajzen (2010) recommended administrating free-response questions to a small sample of people

Table 1.
Sample characteristics

Characteristics	n	%
Gender		
Male	145	35.9
Female	259	64.1
Education		
Middle	01	00.2
High School	122	30.2
Bachelor's degree	180	44.6
Master's or doctorate degree	101	25.0
Age		
18ª- 25	102	25.3
26 - 39	182	45.0
40 - 65	120	29.7
City		
Curitiba	261	64.6
São Paulo	143	35.4
Occupation		
Health (doctor, nurse, psychologist, dentist, etc.)	98	24.3
Education and research (all levels)	62	15.3
Services (lawyer, engineer, architect, etc.)	55	13.6
Administration and business	43	10.6
Public safety (police, fireman)	29	7.2
Commerce and sales	25	6.2
Other (technology, logistics, etc.)	92	22.8
Have driver's license		
Yes	339	83.9
No	65	16.1
Have a car or have access to a car		
Yes	293	72.5
No	46	11.4
No driving license	65	16.1
Home-work distance		
Up to 2 km	68	17.3
From 2.1 to 4 km	56	14.3
From 4.1 to 6 km	51	12.9
From 6.1 to 8 km	43	11.0
From 8.1 to 10 km	32	8.1
From 10.1 to 12 km	36	9.2
More than 12 km	107	27.2
Traffic jams on the way to work		
Intense	105	26.0
Moderate	182	45.0
No traffic jams	70	17.3
Depending on the day	47	11.6
Changed transport modes during pandemic		
Yes	106	26.2
No	298	73.8

COVID-19 Vaccination		
Complete	213	52.7
Incomplete	117	29.0
Not performed	74	18.3
***Contracted* COVID-19**		
Yes	102	25.2
No	302	74.8
Total	404	100

Note. [a] *Age of majority in Brazil.*

who are representative of the study population. Therefore, 33 preliminary interviews were conducted with workers by videoconference to collect beliefs about the choice of transport modes during the pandemic. From these, an anonymous questionnaire was developed and pre-tested.

The questionnaire comprised five sections with questions about: 1) work, routine (e.g., home-work distance) and transport modes used to go to work (at the time of data collection, that is to mean between July and November 2021); 2) TPB factors, including attitudes, subjective norms, perceived behavioral control and intention (when the pandemic ends); 3) changing transport modes during the pandemic and which modes were used before the pandemic started (e.g., "Have you changed the transport mode you were using in November 2019 (before the pandemic started)?"; 4) sociodemographic dimensions (gender, age, education level, city of residence); and 5) COVID-19 questions (vaccination and having contracted the disease). All scales used in the questionnaire were four-point scales. The decision to use even-numbered scales was intended to implement a "forced choice", requiring participants to take a position without the option of neutrality. All questions referred specifically to commuting on the home-work route.

The reliability indices of the final instrument were satisfactory. Cronbach's alpha (α) was 0.90, and McDonald's omega was 0.85.

2.2.1 TPB factors

a) Attitudes

Attitudes about transport modes were assessed based on three topics: 1) what people considered when choosing their transport mode (8 items), 2) perceived advantages and disadvantages of transport choice (13 items), 3) what encourages them to use the stated mode (9 items). For all attitude-related items, a "strongly disagree (1) - strongly agree (4)" scale was used, in which higher scores indicated more positive attitudes ($\alpha = 0.87$).

b) Subjective norms

Participants were first asked to identify which people were important to them, offering eight options: mother, father, husband/wife, brother/sister, boss, friends, son/daughter, and boyfriend/girlfriend. The question was phrased as: "My (mother)'s opinion is important when I choose the transport mode I use to go to work". If participant answered "Agree" or "Totally agree", the person was considered relevant.

The injunctive norm was assessed by asking, for each relevant person, "What is the probability that your (mother) believes that the transport mode(s) you currently use to go to work is the best option for you?" Responses were averaged (on a Likert scale) across all relevant individuals, with scores ranging from very unlikely (1) to very likely (4).

To assess descriptive norms, participants were asked about the transport mode(s) used by each relevant person: "What transport mode(s) does your (mother) use to go to work?" Responses were

categorized into three possibilities: the individual uses the same mode as the participant (2); uses a mode partially shared with the participant (1); or does not use the same mode (0). After that, for each participant, the average value obtained for relevant people was calculated. Thus, for example, if only the mother and father were considered relevant, and the participant used the same mode of transport as the mother —but different from the father— the calculation performed was: (2 + 0)/2 = 1. The sum of two values and the division by two was because only two people were relevant in the example.

*c) Perceived behavioral control (**PBC**)*

PBC was assessed through eight items (α = 0.72): 1) "For me, changing my routine and using another transport mode to go to work would be *very unlikely-very likely*" (1 item); 2) "For me, using another transport mode to go to work if necessary would be *very unlikely-very likely*" (1 item); 3) "My freedom to choose the transport mode I go to work *is very low-very high*" (1 item); and 4) "For me, changing my routine and using a bicycle (e-scooter/motorcycle/walk etc.) to go to work would be *very difficult-very easy*" (5 items).

d) Intention

To measure intention, participants were asked "After the pandemic is over, what transport mode(s) do you intend to use to go to work?". People could check more than one transport alternative.

2.3 Procedure

Data were collected between July and November of 2021. Due to the risk of COVID-19 contamination, data collection could not be conducted in person; thus, an online form had to be used. To access travel habits during the pandemic, participants had to work in person. However, many individuals were working remotely at the time. This situation led us to snowball non-probability convenience sampling procedure (e.g., Leighton et al., 2021; Shafi et al., 2023). Workers in the health and public safety sectors were contacted via social media and asked to participate in the study and to provide the mobile phone number (WhatsApp) of one or more people who could also complete the questionnaire according to the study criteria. Each new participant was asked to suggest another person.

In the education sector, emails were sent to all professors in charge of undergraduate courses at universities in Curitiba and São Paulo who had an institutional email address available on the Internet. The approximate time taken to complete the questionnaire was 20 minutes.

Data was analyzed using the Statistical Package for the Social Sciences (SPSS). Analyses included descriptive statistics (frequencies, means, and standard deviations), chi-square tests, One-Way ANOVA, and binary logistic regression analysis.

3. Results

This section has three topics: 1) descriptive analysis regarding the participants' transport habits before, during and after the pandemic, 2) reasons for choosing transport mode and demographic variables, and 3) TPB and prediction of choosing transport mode behavior.

3.1 Descriptive Analysis Regarding the Participants' Transport Habits

To better understand the transport habits and the influence of the pandemic on the population sampled, we considered for each transport mode the frequencies of use before (November 2019) and during the pandemic (July – November 2021) as well as anticipated use post-pandemic. Table 2 shows the frequency of use of each transport mode for a) people who have not changed their mode of transport (n = 298); and b) people who changed (n = 106) after the start of the pandemic. More than half of the participants were using individual transport modes, e.g., a personal car (n = 246, 60.9%) and app-based ride-hailing (e.g.,

Uber) or taxi (n = 103, 57.6%). Among people who changed their transport mode to go to work during the pandemic, 51.9% did so to reduce the risk of contact with coronavirus. In Figure 1 the transport modes are grouped into three categories (public transport, polluting individual transport and micro-mobility) and the frequency of use before, during and after the pandemic is compared among people who have changed their transport mode.

Regarding public transport use in each city, 33% of Curitiba residents used it before the pandemic, 13% during the pandemic, and 33% intended to use it after the pandemic. In São Paulo, 49% used it before the pandemic, 43% during the pandemic, and 52% intended to use it after the pandemic. In other words, people were more likely to use public transport in São Paulo than in Curitiba, possibly due to the limited options available in Curitiba (bus only).

Table 2.
Choice of mode of transport for commuting to work before, during (current at the time), and after the pandemic (intention), categorized by those who did or did not alter their choice

	a) No change in mode (n = 298)		b) Changed mode (n = 106)		
Mode of transport	**Before/ during the pandemic**	**Intention after the pandemic**	**Before the pandemic**	**During the pandemic**	**Intention after the pandemic**
Car	63.4%	66.4%	31.1%	53.8%	49.1%
Bus	23.2%	30.5%	61.3%	31.1%	50.0%
Ride-hailing/ Taxi	21.8%	21.1%	19.8%	35.8%	21.7%
Walk	12.1%	16.4%	17.9%	22.6%	29.2%
Subway	8.7%	10.7%	19.8%	11.3%	21.7%
Bicycle	5.4%	12.4%	8.5%	12.3%	17.0%
Motorcycle	5.4%	10.1%	3.8%	2.8%	4.7%
Company van	0.3%	0.3%	3.8%	5.7%	5.7%
Train	0.7%	0.3%	0.9%	0.9%	0.9%
E-scooter	0.3%	0.7%	0.9%	0.9%	1.9%
E-bike	0.3%	1.3%	0%	0%	2.8%

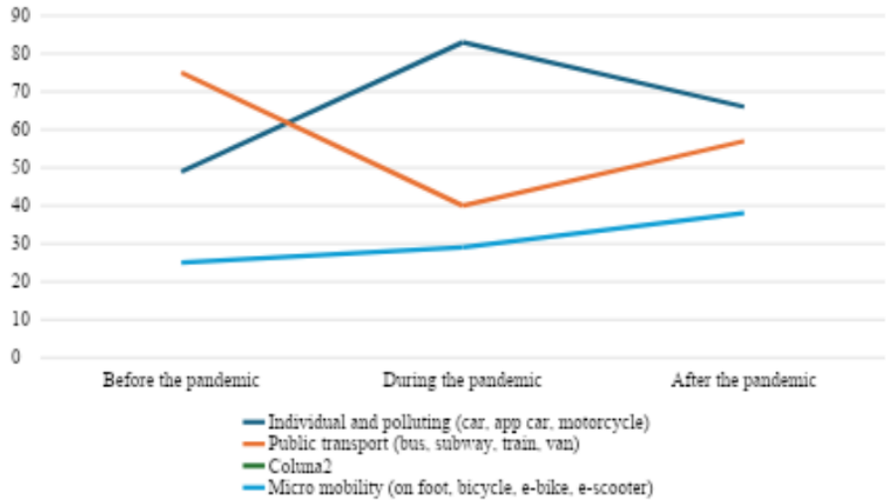
Notes. Questions 1) "Which mode of transport do you currently use to get to work (you can select more than one option)"; 2) "In November 2019, before the start of the pandemic, which mode of transport did you use to get to work (you can select more than one option)"; 3) "Once the pandemic is over, which mode of transport do you plan to use to get to work? (you can select more than one option)".

A chi-square test of independence (2x2) was carried out between using a car before the pandemic (2019, yes or no) and using a car during the pandemic (2021, yes or no). A significant association was found between using a car (χ^2 (1) = 205.17, p < 0.001; ϕ = 0.72before and during the pandemic (hypothesis 1a). Indeed, there was an increase in car use during the pandemic compared to before the pandemic.

Moreover, the transport modes perceived as the riskiest for contracting COVID-19 by the total sample were public ones: bus (M = 3.78, SD = 0.49) and subway (M = 3.77, SD = 5.34).

Figure 1

Participants who changed transport modes (n = 106): use of individual and polluting transport modes, public transport, and micro-mobility before, during and after the pandemic (intention)



The car was considered the least risky (M = 1.51, SD = 0.70). The car was also considered the most comfortable mode (M = 3.70, SD = 0.57) and the bus was rated the least comfortable (M = 1.92, SD = 0.70). Thus, the car was seen as the most comfortable and best mode for preventing COVID-19, and the bus the worst option in terms of prevention and comfort. Regarding intention for the future, a chi-square test of independence (2x2) was carried out using some sustainable transport modes, including public transport, and non-CO2-emitting individual transport (walking, bicycle, e-bicycle, e-scooter), during the pandemic (yes or no) and after the pandemic (yes or no). The results of an association (χ^2 (1) = 192.08, $p < 0.001$; $\phi = 0.69$), showed greater intention to use a sustainable mode of transport in the future. The odds ratio showed that after the end of the pandemic, people were 1.43 times more likely (intention) to use a sustainable mode than during the pandemic.

3.2 Reasons for Choosing Transport Modes and Demographic Variables

To assess what the participants considered when choosing transport modes during the pandemic, a set of eight possible reasons was given (Table 3). For the total sample, the three most relevant reasons for choosing transport modes were time-saving, comfort and avoiding the risk of contracting COVID-19. The risk of a traffic crash and environmental preservation were among the least considered reasons.

Only participants who used public transport before the beginning of the pandemic were selected (n = 162). A one-way ANOVA was used to assess whether there was a statistically significant difference in how these participants considered the fear of contracting COVID-19 between those who had changed (n = 75; mean = 3.6; SD = 0.7) or had not changed (n = 87; mean = 2.7; SD = 0.9) their mode of commuting. There were differences between the groups [$F(1, 161) = 44.66$, $p < 0.001$] (hypothesis 1b). The effect size was est. $\omega^2 = 0.21$.

Furthermore, to dig deeper into the reasons for choosing a particular mode over another, a one-way ANOVA was performed to check whether there were statistically significant differences between the groups (e.g., age, gender, city, and freedom for choosing the mode) in relation to the reasons for choosing the transport mode. The analyses were carried out in accordance with hypothesis 2. Table 4 presents only statistically significant

Table 3.
Reasons for choosing the transport mode (during the pandemic) for the total Curitiba and São Paulo sample

Possible reasons for choosing the transport mode	M[a] and SD - total sample	M and SD - Curitiba sample	M and SD - São Paulo sample
Time-saving	3.55 (0.65)	3.56 (0.65)	3.54 (0.64)
Comfort	3.22 (0.82)	3.25 (0.83)	3.17 (0.81)
Risk of contracting COVID-19	3.17 (0.92)	3.27 (0.90)	2.98 (0.95)
Risk of robbery or theft	3.07 (0.92)	3.08 (0.92)	3.06 (0.94)
Financial cost	3.02 (0.94)	2.97 (0.96)	3.11 (0.91)
Risk of sexual harassment	2.61 (1.06)	2.72 (1.05)	2.41 (1.07)
Risk of a crash	2.49 (0.96)	2.47 (0.93)	2.54 (1.02)
Environmental preservation	2.41 (0.85)	2.38 (0.82)	2.48 (0.90)

Note. [a] Strongly disagree (1) – strongly agree (4).

results; each line will be commented on in detail after the presentation of the table.

People from Curitiba considered the COVID-19 risk more (M = 3.27; SD = 0.89) than people from São Paulo (M = 2.98; SD = 0.95) (hypothesis 2a). Interestingly, there was no statistically significant difference between the three age groups and how much the person considered the preservation of the environment when choosing the mode (hypothesis 2b). However, females were significantly more concerned about the environment (M = 2.48; SD = 0.78) than males (M = 2.29; SD = 0.94).

Regarding the freedom to choose the mode of transport ("I feel free to choose the transport mode I use to go to work"), most participants (n = 323, 80%) declared that they felt free to make such a choice. Interestingly, participants reporting less freedom to make the choice of mode were significantly more concerned about financial cost than those with higher reported freedom (see Table 4). Furthermore, financial cost (M = 3.3; SD = 0.8) was the most considered reason in this group. On the other hand, participants who reported feeling free to make the choice of mode were significantly more concerned about comfort (M = 3.3; SD = 0.8) than those not reporting such freedom of choice (M = 2.7; SD = 0.9) (hypothesis 2c).

When choosing their transport mode, older participants were more inclined to consider the risk of contracting COVID-19, timesaving, comfort, and lower financial cost (see Table 4). The Bonferroni post-hoc test showed that, in all cases, the significant differences were between the "18 to 25-year-old" and "26 to 39-year-old" groups and between the "18 to 25-year-old" and "40-year-old and over" groups. The means and

Table 4.
Comparison between groups (age, gender, city, etc.) on the reasons for choosing transport mode

Dependent variable	Independent variable	Df1/df2	F	p	Effect size est.ω^2
COVID-19 risk	City	1/403	9.53	.002	0.02
Environmental preservation	Gender	1/403	4.67	.031	0.01
Financial cost	Free to choose[b]	1/146.96	12.441[a]	.001	0.03
Comfort	Free to choose[b]	1/106.82	30.221[a]	.000	0.07
COVID-19 risk	Age groups	2/402	4.63	.010	0.02
Time-saving	Age groups	2/402	6.02	.002	0.03
Comfort	Age groups	2/402	12.22	.000	0.05
Financial cost	Age groups	2/402	12.22	.000	0.05

Notes. aWelch's F/ bootstrapping was performed (1000 re-samplings; 95% ci bca).

[b]Feel free to choose the mode of transport (yes or no).

standard deviations for each group in relation to each of these reasons are presented in Table 5.

3.3 TPB Explaining and Predicting Travel Mode Choice Behavior

The descriptive statistics of each TPB factor are described in Table 6 (to verify how each factor was calculated, see 2.1.1). In general, people had a more positive than negative attitude about the transport mode they used and a low perceived behavioral control. Regarding subjective norms, people tended to use some transport modes in common with others deemed important to them and believe that those significant others supported their choices of transport modes.

A one-way ANOVA was performed to compare the TPB results according to gender, city, and age groups (Table 7). In a statistically significant way, people from Curitiba, and those aged over 40, had a more favorable attitude toward their chosen transport modes and used transport modes similar to those deemed important to them more often than people from São Paulo and those aged 26 to 39. Males had a higher PBC than females.

Table 5.
Reasons for choosing the transport mode with significant difference between means of age groups

Reasons for choosing	18-25 years	26-39 years	40 years and over
Time-saving	M= 3.36; SD= 0.73	M= 3.59; SD= 0.63	M= 3.65; SD= 0.56
Comfort	M= 2.90; SD= 0.89	M= 3.26; SD= 0.81	M= 3.42; SD= 0.72
COVID-19 risk	M= 2.93; SD= 0.95	M= 3.24; SD= 0.90	M= 3.27; SD= 0.91
Financial cost	M= 3.37; SD= 0.86	M= 2.99; SD= 0.92	M= 2.77; SD= 0.97

Table 6.
Descriptive statistics of the TPB factor

	n	Median	Mode	M	SD
Attitude*	404	2.98	3.00	2.934	0.415
Injunctive norms*	404	4.00	4.00	3.367	0.755
Descriptive norms**	247	1.00	1.00	1.042	0.703
Perceived behavioral control*	404	2.00	1.75	2.135	0.569

Notes. * Strongly disagree (1) – strongly agree (4).

** Does not use the same transport mode (0) - uses the same transport mode(s) (2).

Table 7.
Comparison between TPB factors between groups

	Gender				City				Age			
	df1/df2	**F**	**p**	**est.ω^2**	**df1/df2**	**F**	**p**	**est.ω^2**	**df1/df2**	**F**	**p**	**est.ω^2**
ATT[a]	-	-	-	-	1/403	7.29	.007	0.02	2/402	9.30	.000	0.04
DN[b]	-	-	-	-	1/246	3.96	.048	0.14	2/246	4.78	.009	0.03
PBC[c]	1/403	24.94	.000	0.06	-	-	-	-	-	-	-	-

Notes. [a]ATT = *Attitude.*

[b]DN = *Descriptive norms.*

[c]PBC = *Perceived behavioral control.*

- not statistically significant.

To examine whether there were significant differences in the attitudes of individuals using private and public transport modes (Hypothesis 3), a one-way ANOVA was performed, using bootstrapping procedures (1,000 re-samplings; 95% CI BCa) and Welch's correction. The ANOVA results showed that there were differences between the groups [Welch's $F(1,75.55) = 143.804$, $p \leq .001$]: individuals who used private transport had more positive attitudes ($M = 3.07$, $SD = 0.33$) toward their chosen mode of transport than those who used public transport ($M = 2.43$, $SD = 0.37$). The effect size was moderate (est. $\omega^2 = 0.30$). To understand to what extent TPB factors can explain the choice of public and individual transport during the pandemic (Hypothesis 4), a binary logistic regression was performed. Nagelkerke's R^2 estimates were used. Each block was added using the Enter method. This regression examined the extent to which gender, age (continuous variable), education level, city, distance between home and work (km), perceived risk of contracting COVID-19, and financial cost were predictors of 1) "(Use of) Car" ($n = 237$) and/or 2) "(Use of) Public transport": choosing public or individual transport ($n = 200$).

In Table 8, each column indicates the accumulated R2, according to the inclusion of the new block of variables (lines). In Table 9, each column indicates the beta and p values of the mode (car/public transport) selected (VIII).

In this model, city, financial cost, attitudes, and descriptive norms were significant predictors of public transport use. The introduction of the TPB factors in the model led to a significant increase in the determination coefficient ($R2 = 0.753$, $R2_{change} = 0.270$). The greatest increase occurred with the introduction of the variable attitudes. The only difference for the prediction of car use was that age was also significant and the greatest increase occurred with the introduction of the subjective norms.

Table 8.
R^2 when predicting the choice of car and public transport to commute during the pandemic

Variables included	Car[a] (n = 237)	Public Transport[b] (n = 200)
I (sociodemographic data: gender, age, education level)	0.130	0.280
II (city)	0.211	0.372
III (home-work distance)	0.213	0.411
IV (COVID-19)	0.260	0.445
V (financial cost)	0.302	0.483
VI (attitude)	0.368	0.712
VII (perceived behavioral control)	0.373	0.725
VIII (subjective norms: injunctive norms, descriptive norms)	0.602	0.753

Notes. [a] Use of a car (even if other modes are used). Note: 9 participants who use cars were excluded from the analysis due to missing data.

[b] Use of the bus, subway, or train without using individual modes (cars, ride-hailing apps service/taxis, walking, bicycles, motorcycles, e-bikes, e-scooters). When people used more than one type of mode (n = 63) or used a company van (n = 7) they were not considered.

Table 9.
Beta and p values of the mode when predicting the choice of car and/or public transport

Variables included (per regression block)	Car[a]		Public transport[b]	
	Beta	p	Beta	p
Gender[c] (I)	0.665	.116	1.486	.085
Age (I)	-0.064	.012	-0.053	.303
Education level (I)	0.107	.674	-0.645	.219
City[d] (II)	1.330	.002	1.980	.013
Home-work distance (III)	-0.014	.417	0.029	.301
COVID-19 (IV)	-0.401	.110	0.096	.816
Financial cost (V)	0.483	.060	1.587	.006
Attitude (VI)	-1.193	.046	-5.677	.000
Perceived behavioral control (VII)	0.043	.903	-1.115	.074

Injunctive norms (VIII)	-0.405	.110	-0.033	.933
Descriptive norms (VIII)	-2.367	.000	-1.318	.026

Note. [a] 1 = use of a car; 2 = no use of a car.

[b] 1 = only uses individual transport; 2 = only uses public transport.

[c] 1 = male; 2 = female.

[d] 1 = Curitiba; 2 = São Paulo.

Table 9 shows that individuals who used cars were most likely from Curitiba and had higher averages in age, attitudes (more positive), and descriptive norms. Individuals who exclusively used public transport were most likely from São Paulo and had higher averages in financial cost consideration, attitudes, and descriptive norms. Additionally, a greater home-work distance increased the likelihood of using public transport, considering the Brazilian socio-economic context.

Given the statistically significant differences between gender and city groups in relation to TPB factors (as shown in Table 7), the same model was applied to specific groups. The R^2 was higher when selecting only females (R^2 for predicting car use = 0.68; R^2 for predicting public transport use = 0.85) and only individuals from Curitiba (R^2 for predicting car use = 0.74; R^2 for predicting public transport use = 0.83).

4. Discussion and Conclusions

This study aimed to understand the choice of transport modes for commuting to work during the COVID-19 pandemic in Brazil. The results confirmed nearly all proposed hypotheses (except Hypothesis 2b) and are consistent with the scientific literature. First, we discuss the impact of the pandemic on the choice of transport mode choices (H1) and the reasons for these choices concerning gender, age, city, and freedom of choice (H2). Second, we examine participants' attitudes toward private and public transport modes (H3) and the TPB factors that predicted mobility choices during the pandemic (H4). Finally, we address the study's limitations and explore how our findings could inform mobility changes in Brazil and beyond.

The primary reason for transport mode selection was time-saving, followed by comfort and the risk of contracting COVID-19. Environmental preservation was among the least considered reasons. The low concern for environmental preservation could be related to the study being carried out during the pandemic, when the focus was on the preservation of life. Indeed, during the pandemic, press coverage focused its attention on cases of infection, deaths, and hospital capacity, not highlighting environmental problems.

Results indicated a preference for private transport modes, mainly the car. As stated in Hypothesis 1a, there was a significant increase in car use during the pandemic, consistent with previous studies (Aaditya & Rahul, 2021; Jenelius & Cebecauer, 2020). Given that Curitiba and São Paulo already had approximately one car per two residents in 2020 (Brasil, 2020b), this increase could exacerbate traffic congestion and air pollution (Guimarães et al., 2021).

Among individuals who used public transport in 2019, fear of contracting COVID-19 was an important variable for mode change, corroborating hypothesis 1b: public transport users who had changed transportation modes since the beginning of the pandemic were significantly more concerned about the risk of contracting COVID-19. Measures are needed to enable these people to use this transport again in the post-pandemic period, such as a free-fare public transport policy (Dai et al., 2021).

Moreover, older people were more concerned about the risk of contracting COVID-19 than younger people. Although this result is consistent with the literature on risk-taking, which shows that young adults take more risks than older people (Steinberg, 2007), one can argue that the high mortality rate of COVID-19 among the elderly (Brasil, 2022) represents a reasonable cause of older people's concern than just risk aversion.

Furthermore, the perceived risk was higher in Curitiba because the mortality rate was higher, confirming hypothesis 2a.

Regarding environmental concern, our study partially confirmed hypothesis 2b, which stipulated that females and older people would care more about it (e.g., Casaló & Escario, 2018). Contrary to our expectations, age had no relationship to how much the preservation of the environment was considered when choosing mode. However, gender showed a significant difference, partially confirming hypothesis 2b: women had a higher score than men on how much they considered the environment in such a choice (Vicente-Molina et al., 2018).

Financial cost was more important among people with low freedom of choice while comfort was the main factor for people with high freedom of choice, confirming hypothesis 2c. These data agree with Maia et al. (2020), in which participants who could pay more for transportation tended to use a private vehicle because it was considered safer and more comfortable, whereas low-income participants needed to use public transport.

In addition, in our study bus was considered uncomfortable (Vasconcellos, 2018) and the riskiest transport mode for contracting COVID-19 (Oliveira et al., 2020). It is, therefore, unsurprising that people who use individual transport modes had significantly more positive attitudes about the transport modes they use than people who use public transport (which confirms the third hypothesis).

Additionally, attitudes and descriptive norms were significant predictors of cars and public transport use. Our model was able to predict 60% and 75% of the result, respectively. This result is in line with the study by Ahmed et al. (2021). As pointed out by both studies, perceived behavioral control was not a significant predictor for cars and public transport choice. Attitudes had the strongest impact on the choice of public or private transport. When making a choice for cars, subjective norms had the most impact. In other words, the transport modes used by the participants' "most important people" had an impact on their choice of the car.

These findings provide valuable insights for interventions promoting sustainable transport and reducing car dependency. Such interventions should involve local authorities as suggested by Bamberg et al. (2021). Indeed, our data suggest that there is a need for more efforts to make the use of buses more attractive and more biosafe, and such information may help inform public policies. Furthermore, if time-saving and comfort are two important aspects for Brazilians when choosing their transport modes, it is important that public transport becomes more agile and comfortable (it would seem plausible that such factors are by no means limited to the Brazilian perspective). By increasing the bus fleet, for example, cities could reduce waiting times and people would be more likely to make their journeys sitting down, in more comfort. Since public transport is the only option for a large portion of the population, buses should have physical barriers between passengers, open windows, and the possibility of social distancing to avoid contamination with viruses.

Although TPB is not a behavior change theory, it serves as a foundation for interventions. Thus, campaigns can aim to improve the population's attitude toward public transport and use the idea of family and friends — shown in our results to be significant factors — to influence people to choose safe and sustainable transport modes. Moreover, the present study showed low perceived behavioral control among the participants for the choice of transport mode. Interventions can be designed to make it clear to people that they can make more sustainable and yet affordable choices. Such campaigns may focus primarily on women, who have significantly lower PBC than men.

The present study also showed how attitudes and lifestyle changes born of the pandemic may shape commuting choices going forward. Our participants stated their intention to use more sustainable transport modes in the future (when the pandemic was over) compared to what they

used during the pandemic. Indeed, high numbers of cars can affect the population's quality of life (Guimarães et al., 2021); thus, public transport could have been replaced by active modes during the pandemic. However, as pointed out by Vasconcellos (2018), the Brazilian road structure is not ideal and must be improved to be made safer. Better quality sidewalks, greater extension of cycle lanes, and proper signs for pedestrians and micro-mobility users could help increase the use of this kind of transport mode. It is believed that if people saw these changes, they might be more inclined to use individual non-motorized transport modes in the future and help reduce congestion and greenhouse gases. However, it is important to highlight the need to focus on road safety by promoting the use of bicycles and e-scooters, emphasizing the correct use of infrastructure and protective equipment.

Our study has two main limitations: 1) the high level of education of the sample (69.6% had at least a bachelor's degree), reflecting a higher socioeconomic level that is not the reality in Brazil and 2) the way in which the sample was selected. Indeed, it was not possible to carry out a random selection of participants. On the positive side, with a higher level of education, our participants had easier access to the online questionnaire (method chosen because of COVID-19 transmission).

In conclusion, our study aligns with the Sustainable Development Goals, such as "good health and well-being" and "sustainable cities and communities" (SDGs; United Nations, 2015) — presents valuable data for the implementation of public policies aimed at sustainability and safety. The results of the study may also find use in the support of public campaigns, in particular drawing on findings about the relevance of attitudes and subjective norms in the choice of transport mode. New variants of the coronavirus or new pandemics may occur in the future. Therefore, it is important that public policies are designed to help people to be safer on public transport or to migrate to transport modes that are healthier for society and the environment in general.

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